PROCEEDINGS OF SPIE

SPIE—The International Society for Optical Engineering

Remote Sensing for Agriculture, Ecosystems, and Hydrology VI

14-16 September 2004
Maspalomas, Gran Canaria, Spain

SPIE P PROCEEDINGS SERIES

Volume 5568

Mapping random and systematic errors of satellite-derived snow water equivalent observations in Eurasia

[1]James Foster, [2]Chaojiao Sun, [3]Jeffrey P Walker, [1,2]Richard Kelly, [1,2]Jairui Dong, and [1]Alfred Chang
[1]Hydrological Sciences Branch, Laboratory for Hydrospheric Processes
NASA Goddard Space Flight Center, Greenbelt, Maryland, 20771 USA
[2]Goddard Earth Sciences and Technology Center
University of Maryland Baltimore County, Baltimore, Maryland 21250, USA
[3]Department of Civil and Environmental Engineering
University of Melbourne, Parkville, Victoria, 3010 Australia

ABSTRACT

Passive microwave sensors onboard satellites can provide global snow water equivalent (SWE) observations day or night, even under cloudy conditions. However, there are both systematic (bias) and random errors associated with the passive microwave measurements. While these errors are well known, they have thus far not been adequately quantified. In this study, unbiased SWE maps, random error maps and systematic error maps of Eurasia for the 1990-1991 snow season (November-April) have been examined. Dense vegetation, especially in the taiga region, and large snow crystals (>0.3 mm in radius), found in areas where the temperature/vapor gradients are greatest, (in the taiga and tundra regions) are the major source of systematic error. Assumptions about how snow crystals evolve with the progression of the season also contribute to the errors. In general, while random errors for North America and Eurasia are comparable, systematic errors are not as great for Eurasia as those observed for North America. Understanding remote sensing retrieval errors is important for correct interpretation of observations, and successful assimilation of observations into numerical models.

I.0 INTRODUCTION

Snow plays an important role in the global energy and water budgets, as a result of its high albedo and thermal and water storage properties. Snow is also the largest varying landscape feature of the Earth's surface. Since Eurasia is considerably larger than North America and more of its land mass is positioned in higher latitudes, its snow cover area and snow volume in mid winter are also greater than for North America. Thus, reliable and accurate measurements of snow extent and snow water equivalent (SWE) in Eurasia are essential for climate change studies and for applications such as flood forecasting.

Passive microwave remote sensors onboard satellites provide an all-weather global SWE observation capability day or night. Brightness temperatures from different channels of satellite passive microwave sensors (hereafter referred to as PM) can be used to estimate the snow water equivalent (or snow depth with knowledge of the snow density), and hence snow cover extent. However, there are both systematic (bias) and random errors associated with the passive microwave measurements. In order for the remotely sensed SWE observations to be useful for climate modelers, water resource managers and flood forecasters, it is necessary to have both an unbiased SWE estimate and a quantitative, rather than qualitative, estimate of the uncertainty (Sun et al., 2004). This is a critical requirement for successful assimilation of snow observations into land surface models (LSMs).

For most PM algorithms, the effects of vegetation cover and snow grain size variability are the main source of error in estimating SWE. Forests can have a significant impact on the accuracy of SWE estimates. In densely forested areas, such as the boreal forest of Canada and Siberia, the underestimation of SWE from retrieval algorithms can be as high as 50% (Chang et al., 1996). In addition, snow density and snow crystal size do not remain constant throughout the snow season everywhere on the globe but rather vary considerably over time and space. PM algorithms are found to be very sensitive to snow crystal size (Foster et al., 1999).

The purpose of this paper is to present a methodology for deriving unbiased SWE estimates for Eurasia from PM observations. Both random errors (those that result from simplifying assumptions used in retrieval algorithms) and systematic errors (those due to the effects of vegetation cover and crystal size) are quantified. This paper presents results for the 1990-1991 snow season, as an example, using data from the Special Sensor Microwave/Imager (SSM/I).

Remote Sensing for Agriculture, Ecosystems, and Hydrology VI, edited by Manfred Owe,
Guido D'Urso, Ben T. Gouweleeuw, Anne M. Jochum, Proceedings of SPIE Vol. 5568
(SPIE, Bellingham, WA, 2004) · 0277-786X/04/$15 · doi: 10.1117/12.564641